10 INTERANNUAL VARIABILITY

Maryland Biological Stream survey (MBSS or Survey) results are presented in this report for basins sampled across three sampling years (1995, 1996, and 1997). We recognize that variation in environmental conditions may influence results from different years. In particular, annual changes in weather conditions can affect stream chemistry, physical habitat, and biological communities. To evaluate the degree to which year-to-year variation in weather conditions may have affected MBSS results, we analyzed variability in precipitation and potential effects on several parameters measured during the 1995-1997 MBSS.

10.1 VARIABILITY OF PRECIPITATION

Across Maryland, 1996 was an exceptionally wet year. January and September were marked by extreme flooding in many areas. According to regional precipitation data (NOAA 1996), the areas sampled by the MBSS received between 20% and 52% more rainfall than normal during 1996. The sample years of 1995 and 1997 were much drier, with regions receiving up to 21% less rainfall than normal (NOAA 1995 and 1997). Statewide, Maryland received an average of 38% more rainfall than normal in 1996. In 1995 and 1997, the State received an average of 7% less rainfall than normal (Figure 10-1). See Appendix D (Table D-1) for summaries of regional precipitation throughout Maryland, during 1995-1997. This difference in annual precipitation was reflected somewhat in the number of dry streams observed during the Survey. During 1996, an estimated 2.8% of stream miles were reported as ephemeral (dry during summer), compared with slightly higher numbers in other years: 5.3% in 1995 and 4.2% in 1997.

10.2 COMPARISON OF RESULTS FOR BASINS SAMPLED IN MULTIPLE YEARS

As part of the MBSS's lattice sampling design (Section 2.1), one randomly-selected basin in each geographic region (western, central, and eastern Maryland) was sampled in each of two separate years to quantify between-year variability in the response variables. The "resampled" basins and the two years in which they were sampled are as follows:

Youghiogheny: 1995 and 1997
Patapsco: 1995 and 1996
Choptank: 1996 and 1997

Data from the same basin collected in two years provide some means of examining annual differences in basin conditions. A more rigorous analysis of trends over time will require additional data from future surveys that span more years.

Nonetheless, the data currently available allow us to examine the degree to which year-to-year variation influenced the interpretation of the 1995-1997 statewide and basin-specific estimates. For example, field data for stream discharge in the resampled basins is compared in Figure 10-2. In the Patapsco basin, mean discharge was much higher in 1996 (4.7 cubic feet per second) than in 1995 (2.1 cfs). In the Choptank, discharge was slightly higher in 1996 (2.8 cfs) than 1997 (1.9 cfs), although these values were within one standard error. In both cases, observed differences were consistent with the greater amount of rainfall received in 1996.

10.3 COMPARISON OF SELECTED BIOLOGICAL AND WATER QUALITY RESULTS FOR BASINS SAMPLED IN MULTIPLE YEARS

For each of the resampled basins, we compared the mean values in the two sample years for the fish Index of Biotic Integrity (IBI), benthic IBI, the Physical Habitat Index (PHI), and nitrate-nitrogen concentration to evaluate the potential importance of interannual variation. In addition, we compared selected results for individual stream reaches sampled in multiple years.

Although some interannual differences in mean values were detected for the fish, benthic, and physical habitat indices, virtually all were within the range of error around each mean estimate (±1 standard error), indicating no significant change from year to year in any basin (Figures 10-3 to 10-5). The only indicator that showed a significant interannual difference was the benthic IBI in the Patapsco basin, where the mean score was significantly lower in 1996 than in 1995. PHI scores in the Choptank basin were slightly lower in 1997 than 1996, although values were within the range of error. Mean nitrate-nitrogen concentrations did not vary significantly between years in any of the resampled basins (Figure 10-6).

Data from individual stream reaches sampled in multiple years provide an additional means of evaluating interannual

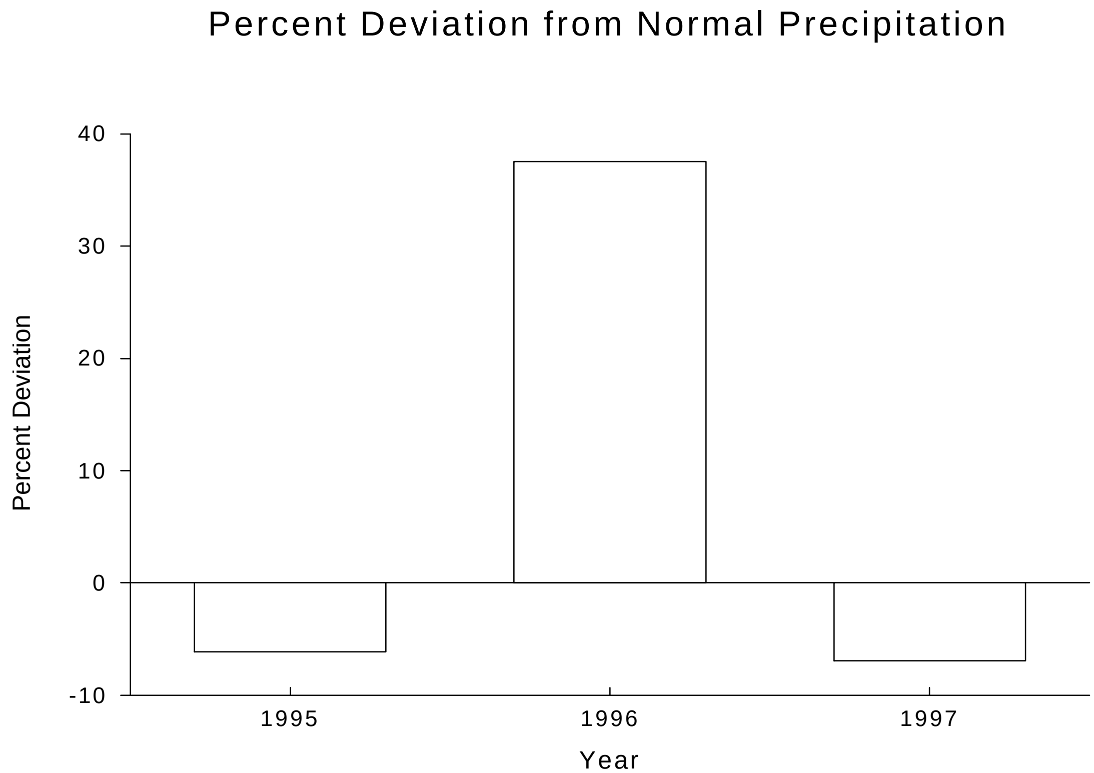

Figure 10-1. Statewide percent deviation from normal precipitation amount for the MBSS sample years 1995-1997 (annual total precipitation)

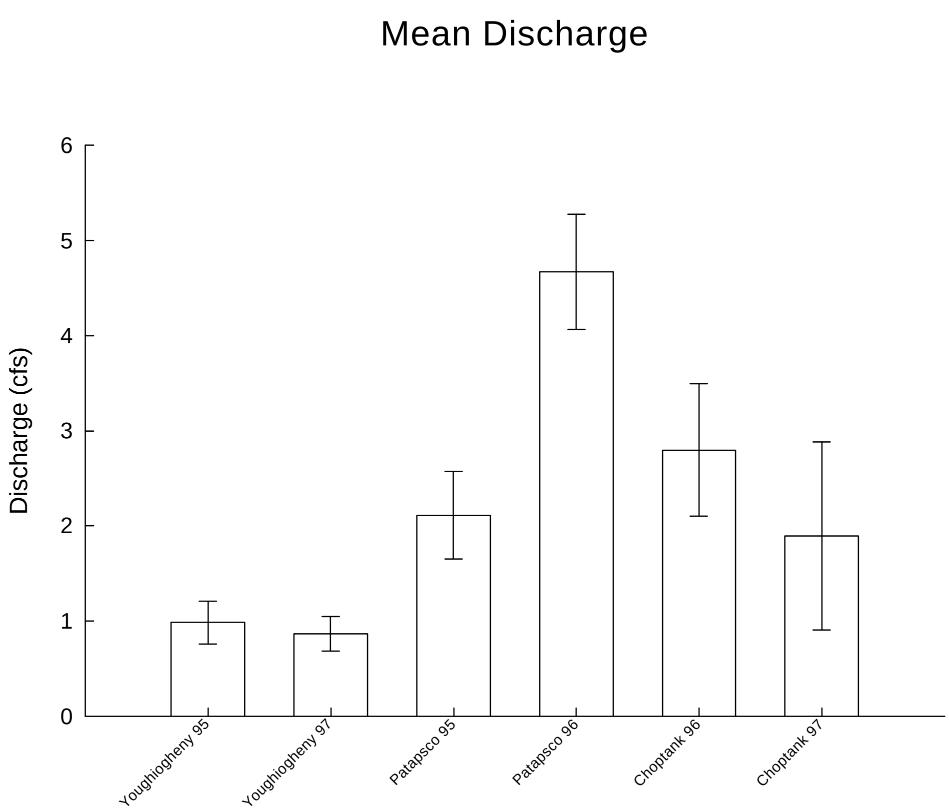

Figure 10-2. Mean discharge (cfs) for the three basins that were sampled in multiple years of the 1995-1997 MBSS. Error bars signify ± standard error.

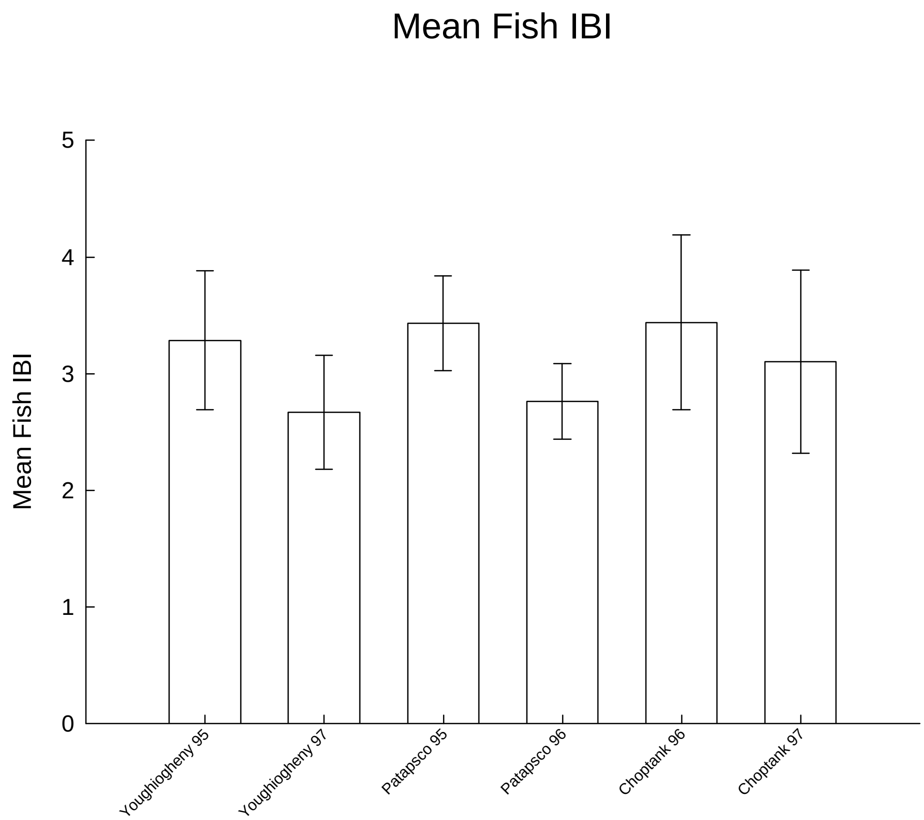

Figure 10-3. Mean fish Index of Biotic Integrity (IBI) scores for the three basins that were sampled in multiple years of the 1995-1997 MBSS. Error bars signify ±1 standard error.

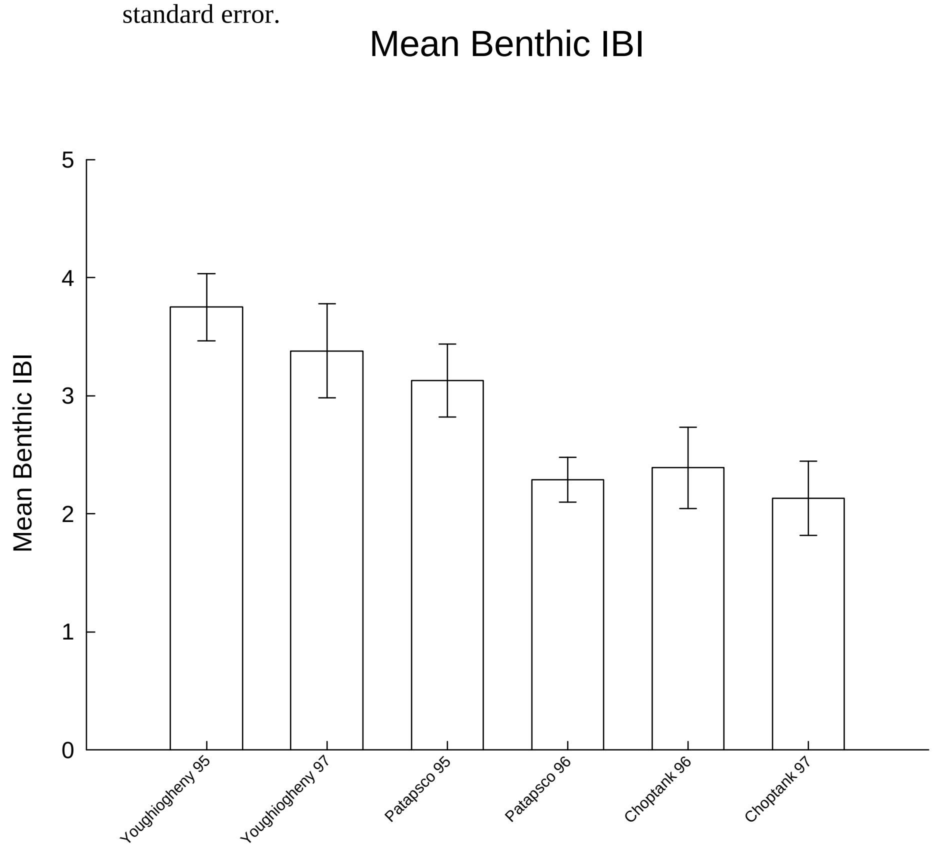

Figure 10-4. Mean benthic Index of Biotic Integrity (IBI) scores for the three basins that were sampled in multiple years of the 1995-1997 MBSS. Error bars signify ±1 standard error.

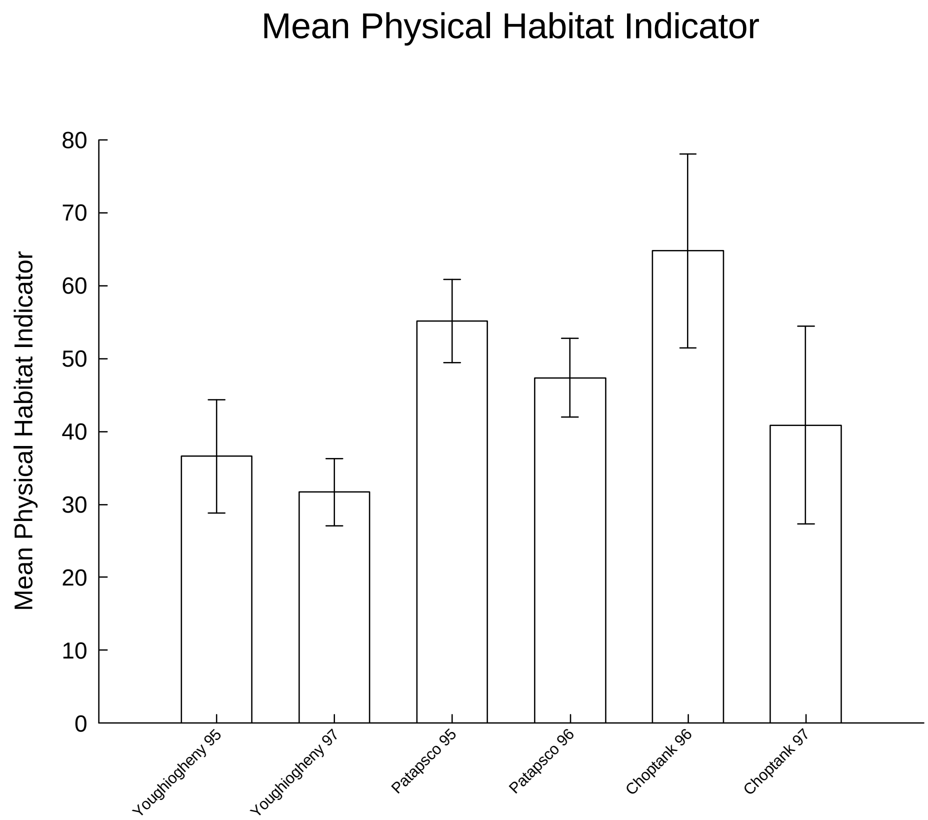

Figure 10-5. Mean Physical Habitat Indicator scores for the three basins that were sampled in multiple years of the 1995-1997 MBSS. Error bars signify ±1 standard error.

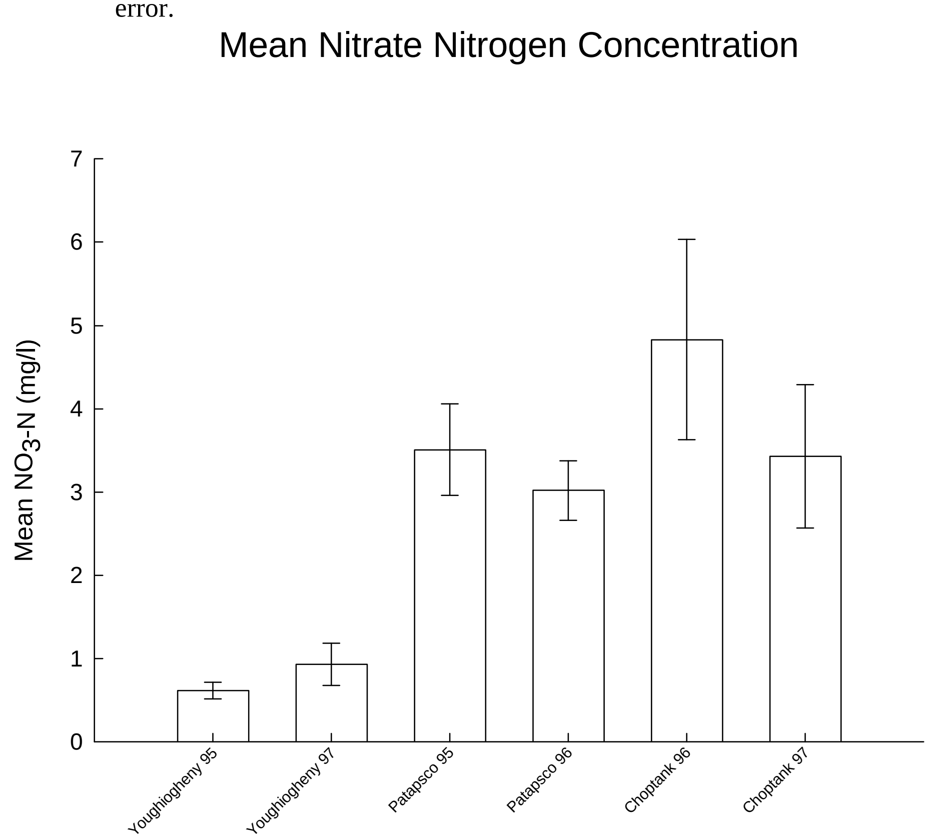

Figure 10-6. Mean nitrate nitrogen (NO_3-N) concentrations (mg/l) for the three basins that were sampled in multiple years of the 1995-1997 MBSS. Error bars signify ± standard error.

variation. As a result of random site selection, 17 stream reaches within the resampled basins were revisited in multiple years: 4 in Youghiogheny, 11 in Patapsco, and 2 in Choptank (Appendix D, Table D-2). Fish IBI, benthic IBI, PHI, nitrate-nitrogen concentration, and discharge for the same reach were compared between years. When more than one site per reach was sampled in a single year, the mean value for all sites in that year was used in this comparison.

At all of the 14 reaches sampled during two summers, discharge changed by at least 10% between years. Except for one reach, discharge was higher in 1996 than 1995 or 1997. In contrast, PHI scores were fairly consistent (within ±15 points on a 100 point scale) at 8 of the 14 reaches. In 1996 sampling of the Patapsco basin, where discharge was noticeably affected by higher rainfall, PHI scores increased at only one reach, decreased at one other, and remained the same at seven reaches, in comparison with 1995 levels. Generally, fish IBI scores were consistent between years (within ±0.5 points on a 1-5 scale) at 7 of 14 reaches. Most of the differences in fish IBI scores were in the Patapsco basin, with decreases noted at 6 of 9 reaches sampled in both 1995 and 1996. However, fish IBI also decreased at one site in the Choptank in 1997 (the drier of two years sampled), and increased at one site in the Youghiogheny in 1997, compared to 1995.

Among the 17 reaches sampled during the spring of two years, benthic IBI scores were relatively unchanged (within ±0.5 points on a 1-5 scale) at 8 reaches. Again, the greatest difference was seen in the Patapsco basin, where 5 reaches had lower benthic IBI scores in 1996, along with 2 reaches exhibiting higher scores and 4 unchanged. Nitrate-nitrogen concentrations were relatively unchanged (within ±10%) at 8 of the 11 resampled reaches in the Patapsco basin. Compared to 1995, nitrate-nitrogen increased at all 4 of the resampled reaches in the Youghiogheny in 1997, but the levels were low and well below the state average.

Although based on a very small number of observations, this analysis suggests that benthic and fish IBI scores may vary slightly from year to year, but are not clearly related to precipitation. Physical habitat ratings were fairly consistent; again, small differences could not be attributed to higher precipitation in 1996. Nitrate-nitrogen concentrations neither increased nor decreased predictably with precipitation. Whether the observed differences were a result of natural variation or human impacts is unclear from this limited analysis. Note that arbitrary thresholds for detecting change were employed; further analyses are required to more rigorously evaluate the variability in IBIs and other results to detect actual trends. Future survey results will provide the information needed to establish levels at which a drop in indicator values signifies a real decrease in stream quality, rather than simply a change owing to natural variability.

In statistical evaluations of the Ohio fish IBI (Fore et al. 1994), the effects of temporal variability and measurement error were small, and the IBI was found to be effective in detecting differences among site conditions. In Maryland, further analysis may be useful to investigate IBI variability, an issue that will be important as these ecological indicators are used to guide management decisions. Ideally, a statistical sampling design would be employed to select a sample of site replicates allowing quantification of temporal (within index periods and across years) and spatial variability.

While the MBSS does not yet provide extensive data to evaluate year-to-year variability in indicator values, some general conclusions can be drawn. First of all, year-to-year variability in important parameters was generally not statistically significant in any of the three resampled basins. Perhaps more importantly, interannual variation in these parameters did not appear to correspond to differences in amounts of annual precipitation. The large amount of rainfall in 1996 did not result in predictably lower (or higher) values for any of the parameters examined, except perhaps for benthic IBI scores in the Patapsco basin. Other possible explanations for the relatively small year-to-year differences that were observed include (1) a general change over time (which could only be addressed by long-term monitoring of basin conditions) and (2) differences in locations of the randomly-selected sites sampled in the two years. One option for distinguishing temporal trends in MBSS data is to design a future sampling component that targets a set of fixed stations for sampling in multiple years. The evaluation discussed above indicates that interannual variability among sampling years in the 1995-1997 MBSS did not significantly influence the composite three-year results. Therefore, no adjustments were made among all basins sampled in different years. Where appropriate, however, results from each year are reported separately for basins sampled twice.